Engine Driven Power Generation
Presented To:
Distributed Energy Resources Road Show

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Distributed Generation: *Chicago Style*

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- Over 100 Distributed Generation (DG) systems are installed in the Chicagoland area.
- Installed systems range in size from 60 kw to over 25 mw
- Average DG installation is 1600 kw to 2000 kw
- 90% of the installations utilize engine driven power technology
- Natural Gas is the predominant fuel of choice
- Most DG systems operate during ComEd's peak energy or demand periods (9am to 6pm or 10pm M-F)
- Most DG systems also provide standby power to their facilities
- Almost all of the installations are owned by the facility
- 50% of the installations have limited or no heat recovery which makes them a power generation system

What is Cogeneration?

- Cogeneration is defined as the simultaneous production of 2 forms of useful energy from a single fuel source. It is also now referred to as Combined Heat and Power
- An example would be a reciprocating generator set producing electricity and hot water using natural gas as a fuel
- Distributed Generation has also been known as:
  - Distributive Energy Resources (Today)
  - Cogeneration (always)
  - Onsite Generation (80's)
  - Total Energy (60's and 70's)

Distributed Generation System Advantages

- Reduces Energy Costs
  - Most facilities can reduce their energy costs by over 25%
- Utilizes Energy More Efficiently
  - A cogeneration system can have an overall efficiency of 70% to 80% compared to a utility generating plant of 30%
- Provides Standby Power
  - Can be used as a standby generator for designated loads
  - Can replace code required standby generator where allowed
- Improves Power Quality and Reliability
  - Provides localized voltage support
  - Provides a semi-interruptible power source

Distributed Generation System Economics

- Most DG systems operate during ComEd's peak demand or energy periods
  - The average cost of power is 10 to 14 cents per kWh during the peak periods and 2.5 cents per kWh during off peak periods
- Most DG systems can produce power for approximately 5-6 cents per kWh
  - Natural Gas cost 4 cents per kWh
  - DG system maintenance cost 1 cent per kWh
  - ComEd Rate 18 standby cost 1 cent per KWh
- A typical 1000 kW DG system can save $135,000 to $200,000 annually depending upon fuel cost and heat recovery

Distributed Generation System Economics

- A 1000 kW DG system is typically installed for $900 to $1200 per kW
- Factors that impact DG installation costs
  - Packaged vs. site constructed
  - Location on site in respect to electrical services and thermal usage points
  - Site modifications required such as a structure for the cogeneration system (approx 1 square ft/ kW)
  - Utility electrical interconnection costs
- Most DG systems have a payback of 4 to 7 years but…
  - Payback can be reduced to 2 to 5 years if a standby generator set was going to be installed

Who Are The Candidates For Distributed Generation

- Hospitals
- Industrial Facilities
- Schools
- Institutions
- Office Buildings
- Just about anybody who needs a standby generator or has a concern about power reliability!

Engine Generator Characteristics

- Types of Engine Generators
  - Naturally Aspirated
  - Turbo-Charged
- Types of Engine Generator Fuel
  - Diesel (100%)
  - Spark ignited (Natural gas, bio gas)
  - Dual Fuel (Diesel pilot)
- Engine Generator Speed
  - Standby Diesel 1800 rpm
  - Standby Natural Gas 1800 rpm, 1200 rpm
  - Cogeneration 1800 rpm, 1200rpm, 900 rpm

Engine Generator Characteristics

- Engine Generator Combustion
  - Standard (Typically requires catalytic converter)
  - Lean Burn
- Engine Generator Efficiencies (Btu's In)
  - Electrical 30 to 36% HHV
  - Jacket water 30% (180F to 200F typical)
  - Exhaust Heat 15% (180F to 350F typical)
- Engine Generator Ratings
  - Typical Voltages include 120/208, 277/480, 4160 vac
  - Above 4160 vac a step-up transformer is typically used
  - Power factor .8
  - Fault contribution relatively small compared to utility

Engine Generator Maintenance

- Maintenance on natural gas generator sets can range from .6 to 2.0 cents per kWh depending on:
  - Size and speed of genset
  - Electrical load factor
  - Balance of plant
- Using actual annual maintenance costs from equipment suppliers is the best approach
- Key engine generator maintenance items include:
  - Oil and filters: 1000 hours
  - Turbocharger rebuild: 10,000 hours
  - Top end overhaul: 12,000 to 20,000 hours
  - Major overhaul: 25,000 to 40,000

Distributed Generation System Description

- Engine Generator Set
- Radiator
- Jacket Water Heat Exchanger
- Exhaust Heat Exchanger
- Generator Controls
- Paralleling Switchgear and Protective Relays
- Enclosure or Building

Natural Gas Distributed Generation Generator Set (1100 kW)

Distributed Generation Paralleling Controls and Switchgear (2000 amp)

Packaged 265 kW Standby Genset

Types of Engine Applications

- Standby Generator sets
  - Diesel or Natural Gas
  - Operating hours under 500 hours annually
  - Provides standby power to dedicated loads
  - Can be used as peak shaving for utility demand limiting
  - Can be used for interruptible electric utility rates
- Distributed Generation
  - Natural Gas or Bio gas
  - Provides reduced energy operating costs to facility
  - Operating hours in Chicagoland 2300, 3300 and 8760
  - Generally provides standby power to facility
  - Provides improved power reliability and voltage support
  - Generally operates “Base Loaded” during the electric utilities peak periods

Cogeneration Related Standards

- National Fire Protection Association (NFPA)
  - National Electrical Code
  - NFPA 37: Installation and Use of Stationary Combustion Engines and Gas Turbines
  - NFPA 110: Emergency and Standby Power Systems
- Institute of Electrical and Electronic Engineers (IEEE)
  - Various Standards and Papers
- ComEd
  - Guidelines for Interconnection of Generation to the ComEd System (Blue Book)

Electric Utility Interconnection

- Types of Electric Utility Interconnection
  - Open transition transfer switch
  - Closed transition transfer switch (make before break)
  - Paralleled circuit breaker
  - Isolated operation (No utility interconnection)
- Utility Interconnection Issues (Safety)
  - Back feed of utility electrical system during an outage
  - Synchronism of genset to the utility
  - Synchronism of utility to genset during a reclosure operation

ComEd Electrical Interconnection Requirements

- ComEd Interconnection Plans
  - Plan “A” 25 to 2500 kVA
  - Plan “B” 2500 to 10,000 kVA
  - Plan “C” 10,000 kVA and above
- Must also meet 50% minimum line loading requirement
  - Most 1000 kW and above DG systems require ComEd Plan “B” interconnection due to minimum line loading
- Typical DG system ComEd interconnection review, approval and modification implementation is 6 months

ComEd Electrical Interconnection Requirements

- ComEd Interconnection Costs
  - Plan “A” $2500: Generally requires no line modifications
  - Plan “B” $80,000: Generally requires line re-closer upgrades
  - Plan “C” $150,000+: Generally requires line re-closer upgrades and remote communications (Transfer trip)
- Other System Interconnection Requirements
  - Momentary parallel operation for less then 1 minute generally permitted without special interconnection requirements
  - Parallel operation on the ComEd low voltage network system is not allowed
  - Special modifications are required when paralleling thru an ATO

Brookfield Zoo Distributed Generation System

- Brookfield Zoo System Description
  - (2) 1100 kW natural gas lean burn gensets (No heat recovery)
  - (1) 1600 kW diesel genset
  - Specialized 4160 volt generator controls and paralleling switchgear
  - Dual ComEd 12.47 kV feeders and transformers
- System Operation
  - ComEd peak energy hours during the summer
  - ComEd peak demand hours all other times
- Unique Features and Benefits
  - Saves Brookfield Zoo over $ 500,000 annually
  - Provides site voltage support during summer periods
  - Operates isolated from utility grid during major storms
  - Provides minimum operational support upon failure of both utility feeders and 2 of 3 gensets

Brookfield Zoo Distributed Generation System (Engine Room)

Brookfield Zoo Distributed Generation System (Switchgear Room)

Let's Review

- Distributed Generation is a cost effective way of:
  - Reducing Energy Costs
  - Providing Standby Power
  - Improving Power Reliability
  - Using Energy Resources More Efficiently
- Distributed Generation Is A Proven Technology
  - Over 100 systems in the Chicagoland area
- Distributed Generation Is Cost Effective
- So What's The Problem?

Barriers to Distributed Energy Resources

- Perception and Attitudes
  - End User
  - A/E Firms
  - Equipment Suppliers
- Electric Utility (Things Have Improved But…)
  - Interconnection costs account for 8 to12% of a 1000 kW project
  - Very little incentive to promote cogeneration
  - New generation automated distribution systems may not be compatible with distributed generation systems without costly modifications
- Distributed Generation Economics
  - Installation costs
  - Natural gas and electricity costs

Reliable Power Dual *Chicago Style* Packaged Generation Unit

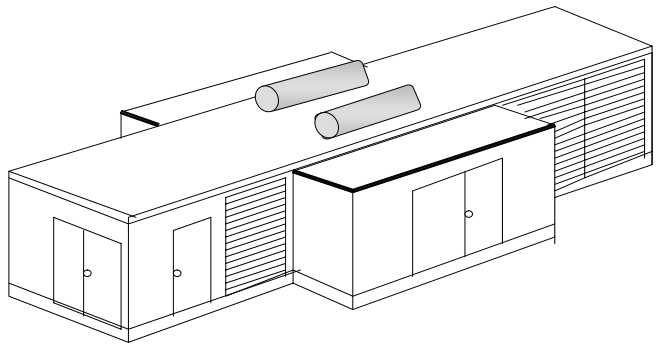
- *Goal:* Provide facilities with an opportunity to install a cost effective distributed generation system that:
  - Provides redundant standby generation sources that can be used for cogeneration in the City of Chicago
  - Meets 10 second standby genset start requirements
  - Increases power reliability
  - Reduces energy costs
- Design a product specifically to comply with the City of Chicago requirements for Emergency Generators to operate as Cogeneration Use (Article 701,18-27-701.15)

Reliable Power Dual *Chicago Style* Packaged Generation Unit Features

- Completely packaged dual (2) natural gas generator sets:
  - Provides 400 kW required for standby generation
  - Provides 800 kW for distributed generation for energy savings
  - Complete generator controls and paralleling switchgear for ComEd interconnection. (Protective relaying and Rate 18 metering)
  - Jacket water heat recovery is optional
  - Diesel generator sets are optional
- Compartmentalized into 4 sections optimized for use and environment
  - Gensets
  - Generator controls and paralleling switchgear
  - Air inlet and Baffles
  - Radiator

Chicago Style Packaged Unit

Reliable Power
Chicago Twin Packaged Power



Reliable Power Dual *Chicago Style* Packaged Generation Unit Features

- The packaged unit is
  - Designed specifically to comply with City of Chicago codes
  - Factory assembled and tested
  - Requires minimal site assembly
  - Sound attenuated to approx 72db @23’
  - Allows ample working clearance around genset
  - Utilizes standard design for lowest cost and highest quality
- Generator controls and switchgear:
  - Designed specifically to comply with City of Chicago Codes
  - Designed specifically to comply with ComEd interconnection relaying and metering requirements
  - Provides separate cogeneration and standby load connections
  - Utilizes “State of the Art” PLC control and remote monitor systems
  - UL listed

Reliable Power Dual *Chicago Style* Packaged Generation Unit Benefits

- Complete Package
- Provides “One Source” responsibility
- Provides reduced installation costs
- Provides improved quality
- Provides a “Win- Win” situation to meet City of Chicago requirements and reduce energy costs

Questions/ Comments